Operational Benefits of Transitioning the

Traditional Voice-based Controller/Pilot COM Radio System

to Digital Technology

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AIR TRAFFIC MANAGEMENT SYSTEMS

**Air/Ground COM is the most fundamental element of Air Traffic Control**

Characteristics

Characteristics of the traditional overland VHF COM system

- **Voice based - global standard**
- **Limited to aeronautical mobile** (117.975-137.000 MHz using 8.33 or 25 KHz spacing)
- **Air-to-air <u>and</u> air-to-ground voice radio**
- **Little end-to-end message delay time** (within 250 milliseconds)
- **Single partly line radio channels** (everyone hears the talker)
- **Affordable avionics for all general aviation and commercial air transport**
- **Affordable cost of ownership for Infrastructure - ATS service provider** (FAA)

Requirements of a next generation voice COM system

- **Maintain all of the above characteristics … voice-based**
  - **Provide more channels to handle increased capacity**
  - **Reduce RF interference**
  - **Provide security features**
  - **Enhance safety features**
  - **Provide efficiency tools to ease controller & pilot workload**
  - **Support remote maintenance & monitoring**
  - **Easily implementable, no "big bang" avionics equipage or mandated "*unpractical*" avionics requirements ruling**
  - **Robust for future growth & features flexibility**
- **Interoperable with future datalink applications**

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Digital Radio Technology

VDL-3 uses TDMA (Time Division Multiple Access) **technology used in cell phones**

- **Management signal within each channel for robust features**

- **Continuous reservation, management polling beacon**

- **Enables proactive channel control**

- **Priority message handling before bottlenecks occur**
  (versus CSMA – Carrier Sense Multiple Access which is contingent based access - 1st user gets channel until message transfer is complete, some message transfers will be compromised)

- **Digital data along with voice that can be used for display to users**

- **Channel multiplexing, up to 4 channels per 25khz frequency spacing**

- **Data or voice** (encoded to digital format) **in each channel --- a single radio system for both!**

TDMA Frame (120 ms)
(~ 8 per second)

Slot A	B	C	D

Mgmt	Voice or Data
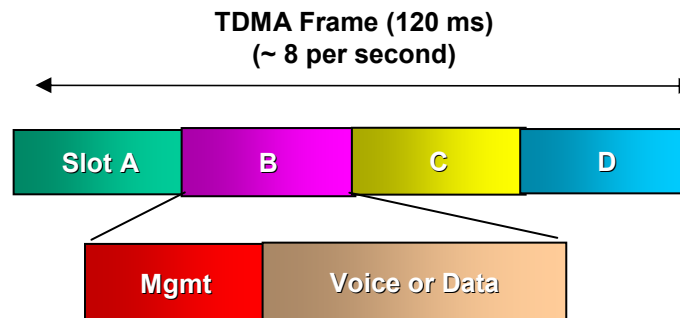
Digital for ATC COM Applications

Features of FAA's VDL-3 digital voice

- **Robust controller & pilot channel control**
  - Anti-blocking / voice step-on avoidance
  - Pilot's urgent (downlink) message request
  - Controller override capability
  - Stuck microphone resolution
- **Robust controller & pilot human factors interfaces**
  - Uniform clarity of voice reception
  - User (controller) authentication
  - Talker Identification
  - Aircraft logged-in identification
- **Reduce workload with automation & aids**
  - Channel status indicators & queries
  - Next channel uplink

Potential digital datalink applications

- CPDLC (text messaging)
- Conflict alert warnings
- Integrating ground automation systems / air based flight management systems

Voice Step-on Avoidance
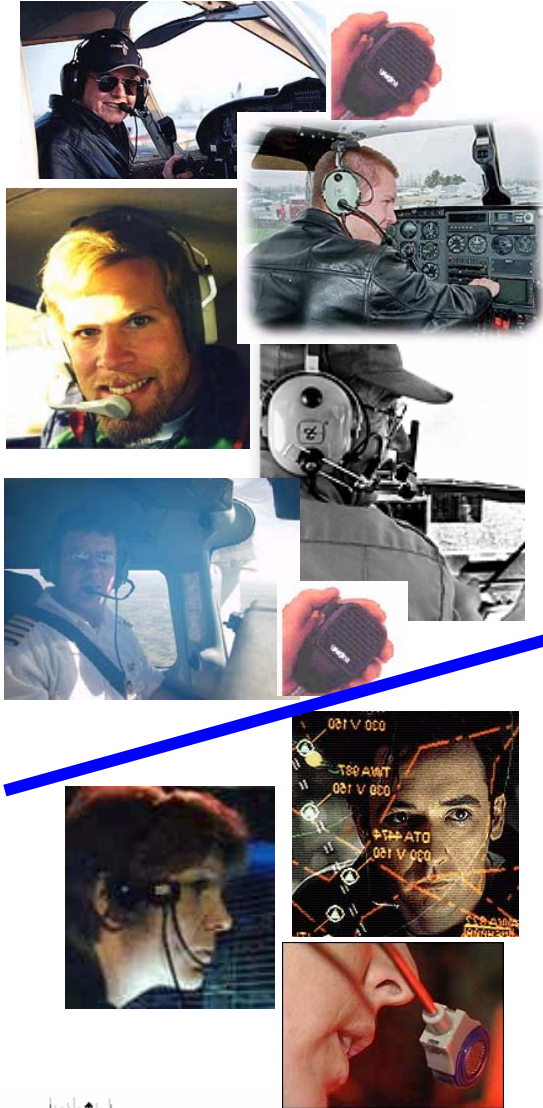
Operational description

- PTT (push-to-talk switch) of radios blocked if channel is busy.

How it works

- Ground based beacon channel indicates to all users who has the voice channel.

Controller & pilot human interfaces

- User hears a tone in headset indicating channel is busy if PTT key is suppressed (similar to telephone system operation).

The driving need & benefits

- Blocked radio transmissions represent a significant safety hazard, contributing to aircraft accidents including the worst airline accident in history. The 1977 collision of two Boeing 747s at Tenerife (Canary Islands), in which 583 people were killed. A blocked radio transmission caused one crew to mistakenly conclude they were cleared for takeoff while the other 747 was still on the runway.

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Pilot's Urgent Request Signal
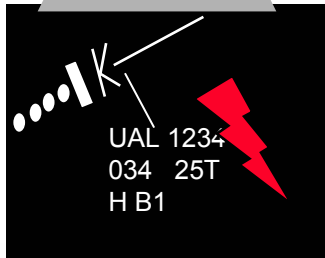
Operational description

- Pilot presses a button that sends a signal to the controller indicating an emergency and the pilot needs to talk.

- Controller authorizes requesting pilot.

How it works

- Signaling channel used to transfer information to ground station and thence to controller.

Controller & Pilot human interfaces

- "Hot Button" available in the cockpit to pilots

- Controller gets alert indication on the glass next to sending aircraft as well as audio alarm.

The driving need & benefits

- On 9/11/01, on American Flight 11, the pilot apparently keyed a microphone switch on his control yoke, allowing ATC to listen to his conversation with a heavily accented hijacker, as the pilot pleaded with the hijacker.

UAL 1234
034   25T
H B1

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Controller Override Control

Operational description

- The controller is allowed access to a communication channel even if it is in use.

How it works

- Ground based beacon source indicates special controller occupancy turning off airborne transmitters.

Controller human interface

- "Channel override switch" on ground controller's voice switch panel.

The driving need & benefits

- In critical situations where the controller needs to take charge of the COM channel, such as when a aircraft's MIC is stuck, or the controller must pre-empt all voice traffic from aircraft, this function will enable the controller to control the channel.

Stuck MIC Resolution

Operational description

- Controller sends a broadcast signal to all aircraft that turns off all aircraft radios PTT switches.

How it works

- Same ground beacon that provides controller override capability turn off the airborne transmitters.

Controller human interface

- Discrete button on controller's voice switching & control panel (same as controller override).
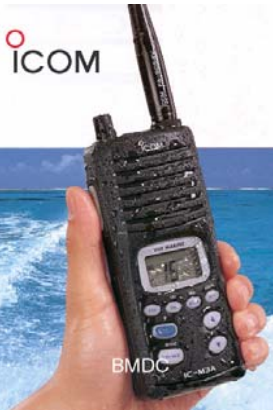
The driving need & benefits

- Eliminates accidental or intentional channel jamming - when the MIC is keyed.

User Authentication

Indicator that controller is talking

Operational description

- Voice: Indicator in cockpit shows which messages are transmitted by controller.

- Data: Radios authenticate each other before a datalink exchange occurs.

How it works

- Voice: Only controllers are allowed "log-on" access to controller's workstation & radio. Ground voice ID only available to FAA controlled radios.

- Data: During datalink initiation the air and ground exchange authentication parameters.

Controller & pilot human interfaces

- "Log-on" passwords required by controller and pilots before using radios (for voice and/or data).

The driving need & benefits

- Eliminates "phantom controllers" whether provided by malicious intent or accident (such as pilot leaving handheld COM radio on the kitchen counter and child uses as a toy).

Talker Identification

Talker Indicator

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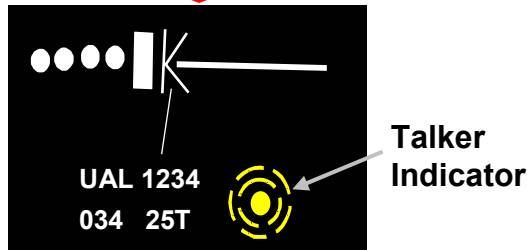
Operational description

- The controller gets an indicator display of which aircraft is talking with every voice message received.

How it works

- A user ID is included in each message signal.   Each aircraft's ICAO address is filed with the flight plan and is correlated to the flight number by the automation system. The talker is identified next to the flight data block flight number on the controller's display.

Controller human interface

- Controller is provided indication of speaker in association with the flight data block.

The driving need & benefits

- Assists with controller's cognitive workload, like the "old fashioned direction finding line of bearing", provides controller with identification of speaker and assists in specific location.

- Helps eliminate call-sign mis-communication.

Next Channel Uplink

sector
boundary

next
channel

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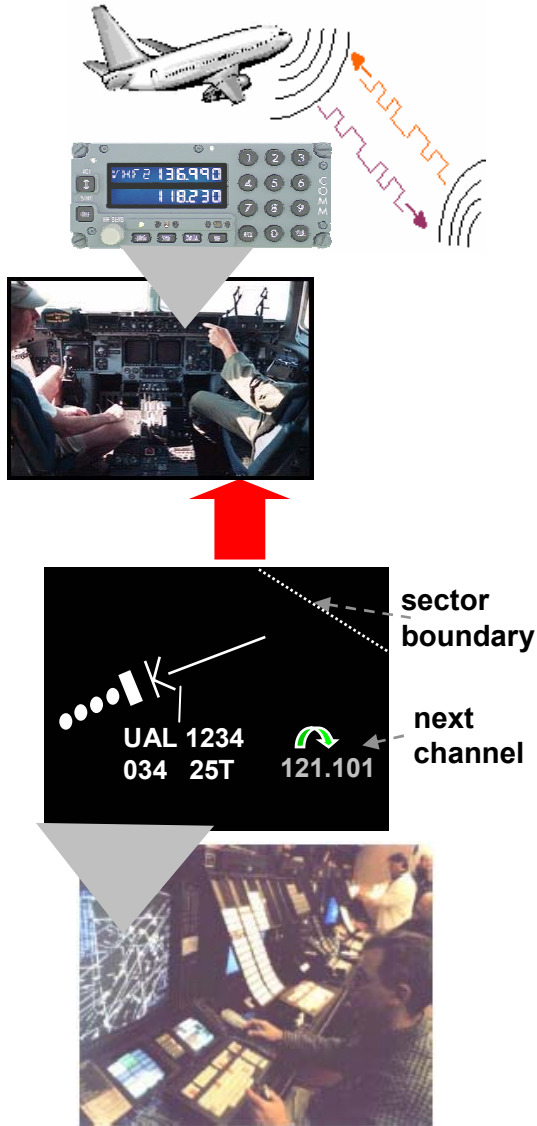
Operational description

- The next radio channel setting for a new sector is automatically provided to the controller and pilot, reducing their workloads.

How it works

- Controller: Current automation systems already provide notice to controllers for a sector transfer. The automation/COM system adds a send next channel uplink signal.

- Pilot: The next channel is automatically displayed on the aircraft radio, via the next channel uplink signal.

Human interfaces

- Controller: The controller is presented with a inquiry to confirm transmission of the next channel uplink signal.

- Pilot: The aircraft radio displays the next channel. The pilot then can accept this next channel for radio tuning.

The driving need & benefits

- Manual sector hand-offs account for nearly 40% of controller's COM workload.

Aircraft Log-In Indication

List line no.	Aircraft ID	Beacon code	Log-in	Channel
001	UAL234	2330	yes	120.101
002	DAL1012	2145	NO	
003	KLM449	2444	yes	120.102
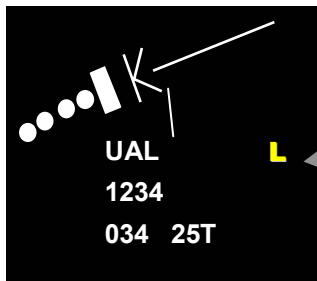
Operational description

- The controller can identify which aircraft are logged in to the user group for a specific sector (have digitally equipped enhanced voice radios and tuned to appropriate frequency).

How it works

- Users logged into the ground networking equipment are tracked in databases and information is available through controller's automation system.

Controller human interfaces

- Indication on controllers screen flight data block.

- Query list available (logged on or unknown).

The driving need & benefits

- Controller's can be assured enhanced voice aircraft are tuned and able to listen to other aircraft and controller within the sector.

CHI Tools to Assist the Controller with Voice COM Workload
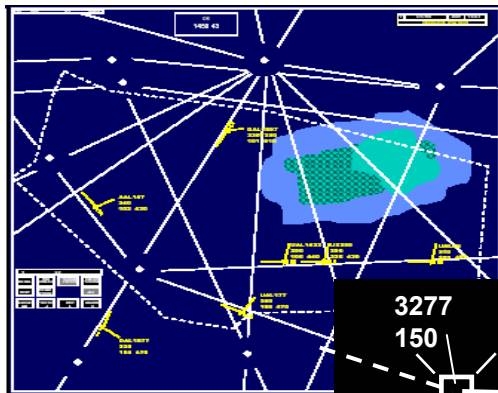
Channel Status Indicator Lights

120.101

🔴 **Channel Busy**

🟢 **MIC Keyed (PTT enabled)**

⚪ **Controller Override**

Voice Switch Control Enhancements

Interactive Flight Data Block Enhancements

3277
150

UAL131 H
DC10 I MSP
160 05 090

Menu Driven Query Lists

Toolbar Display

Display Window (Aircraft List)

Icon Box Display

List line no.	Aircraft ID	Beacon code	Log-in	Channel
001	UAL234	2330	yes	120.101
002	DAL1012	2145	NO	
003	KLM449	2444	yes	120.102

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Digital Link for Data

**VDL Mode 3 Offers COM Channels that may be used for datalink usage**

- Effective 3kbps/channel under all traffic volume

- Near real time (within 360 ms delivery)

- Cost of ownership to:

    - Ground infrastructure owner - ANSP datalink capability within voice COM infrastructure

    - Avionics (same RF modem (D8PSK) as popularly equipped VDL-2 avionics)

- 4 channels (for use as voice or datalink)

- Signaling channel embedded in each polling beacon

- Reservation request to ground - prioritized data transfer - guaranteed exchange

- ATN highly efficient message encoding schemes (standard CPDLC text), prioritized

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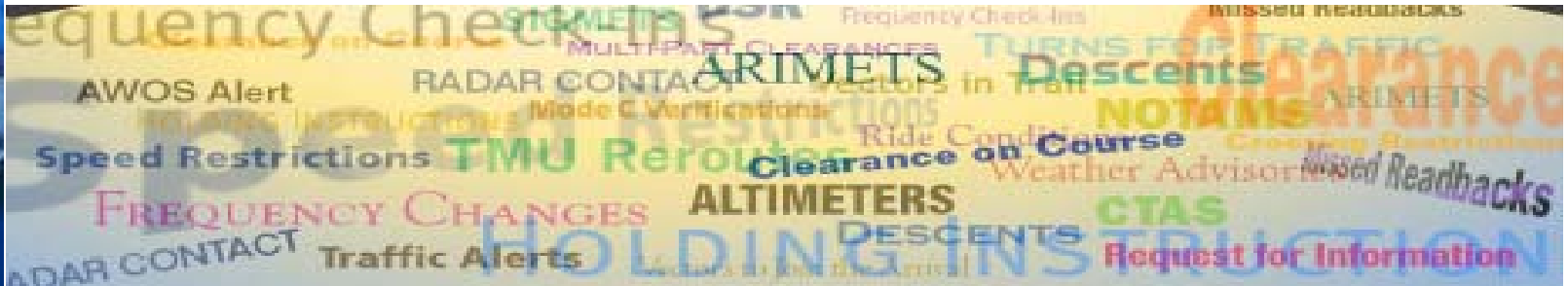
Implemented Datalink Applications

- **Data exchange for AOC use since 1978**
- **Tower Data Link Services @ 57 busiest airports in US**
- **Private weather reports**
- **ADS/CPDLC - aircraft position reporting over oceanic airspace**

Graphics & Text
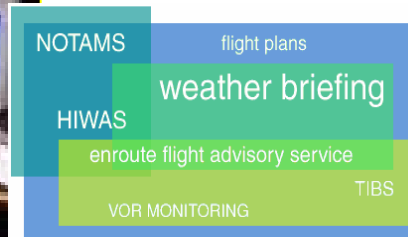
Future Applications?

- Conflict alert notifications
- Computer-to-Computer data sharing between airborne flight management systems & ground based automation systems
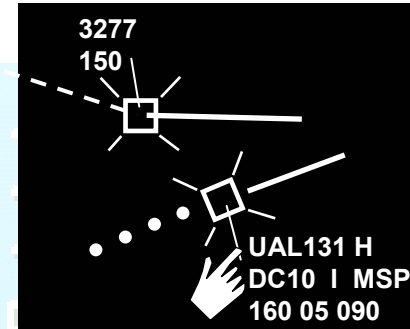
ATC Datalink is a common element in most new applications related to ATC modernization and airspace management

CPDLC Text Messaging

- Addressed point-to-point (controller / single aircraft) … alleviates voice congestion

- Mutual verification of information passed between a controller and the involved aircraft alleviates problems with **Readback Hearback**

Graphical User Interfaces – "*Eye Gate*"
- **Interactive flight data blocks**
- **Point & click cursor addressing**
- **Menu driven windows**
- **(ICAO) standard message set** (small data sizes)

Synthetic Voice User Interface Feasible – "*Ear Gate*"

EnRoute Flight Management Aids

Predicted conflict analysis and conflict alert notification
- Ground automation systems to cockpit
- Airborne flight management systems to ground controller

Utilizing 4-Dimensional trajectory modeling (LAT, LONG, ALT and Time)

TCAS alarm could cause VDL Mode 3 urgent downlink request
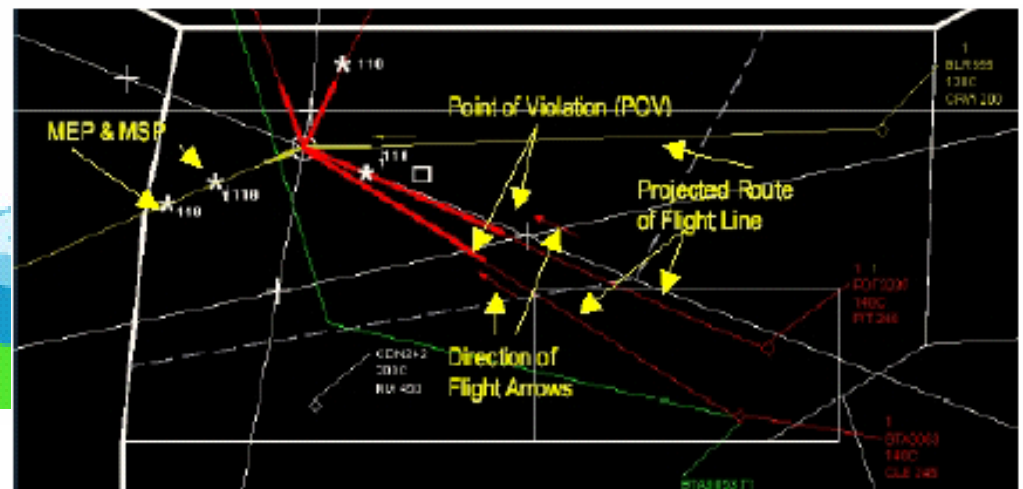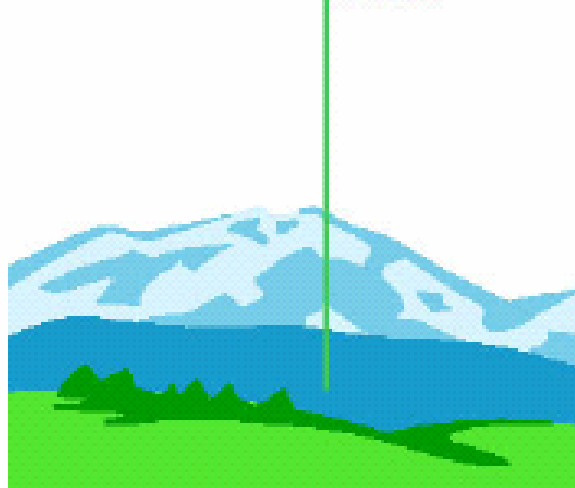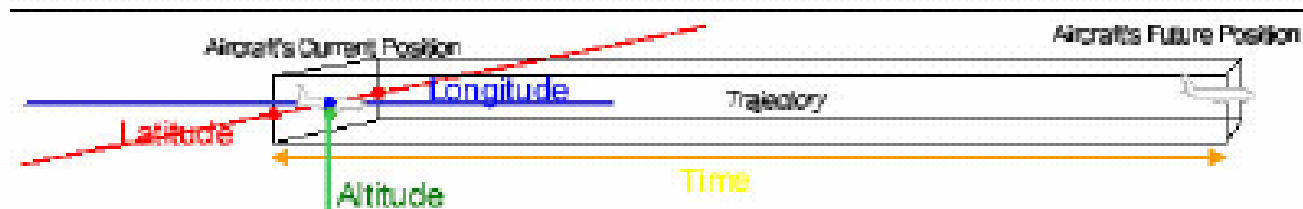
Dynamic Routing in Terminal Airspace

Ground based automation systems linked with airborne flight management system
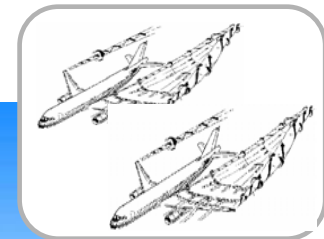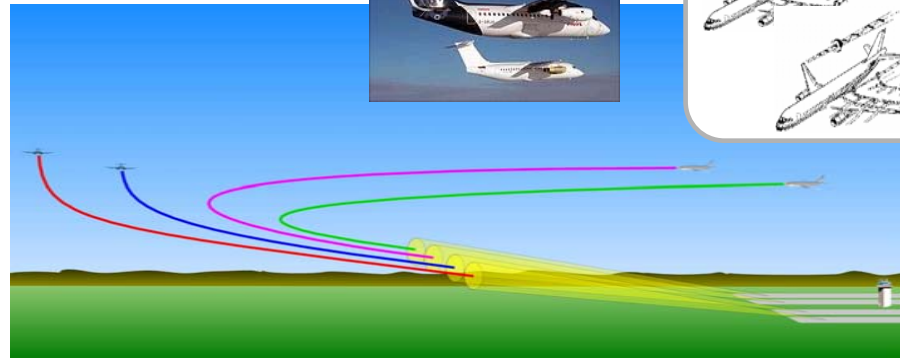
Continuous descent arrival with throttle settings (steady) at just above idle

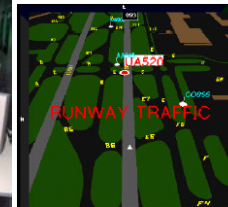**Un-manned / non-tower small airport ATC operations**

Parallel vs. serial arrival staging for closely spaced parallel runways enabling wake vortex avoidance

Final Approach Trajectory Control

Terminal Area Conflict Alert Notification

Link ground based surveillance/automation systems with the cockpit

- AMASS, ASDE-X, PRM, STARS FMA

- Provide automatic conflict alert notification *(audio tone, synthetic voice, and/or text message)*

- Speeds up warning, before controller provides voice messages

- Runway incursion, surface incursion and final approach spacing monitoring

- ITWS (weather) and Wind Shear alert broadcast

ATM World Requirements

The main challenges for today's Air Traffic Management (ATM) are clear:

- An urgent need for integrating the airspace, increasing capacity, while enhancing safety.

- ATC communications, the very backbone of today's ATM, have to break through the next technological sound barrier, in order to turn these requirements into solid sound solutions.

Digital voice is an important enabler for applications as a transitional step towards the future of nearly autonomous free flight.

Crew

Controllers
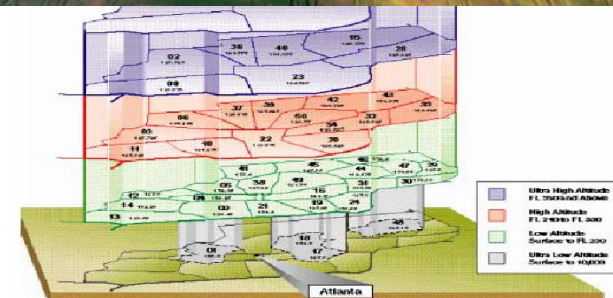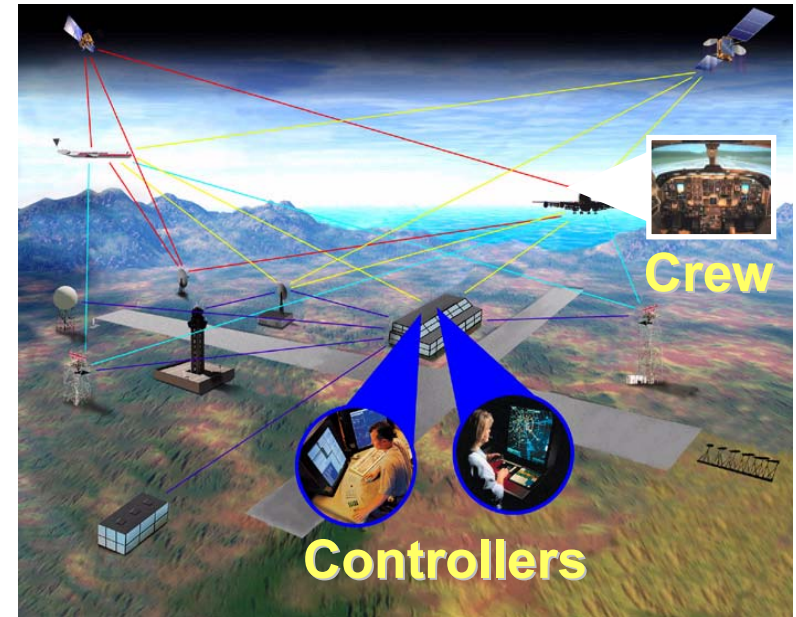
Modern air-ground communications utilize digital techniques not only to keep up with the general technological trend but to offer real operational benefits to the providers and users of air traffic services.

Benefits of Transitioning to Digital Technology

Reduce fuel burn

Reduce flight time

Increase schedule integrity

Increase trajectory and arrival predictability

More efficient use of airspace

Reduce pilot and controller workload

Reduce need for holding

Reduce need for radar vectoring

Reduce voice congestion

Reduce emissions and noise

Increase controller confidence in aircraft track, altitude, speed & intent

Increase safety and security

Business Case

Integrating COM with NAV & Surveillance for Air Traffic Management in the NExTNAS

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What's left to do

- **Computer Human Interface (CHI) - design, experiments and tuning**

- **Performance *(for various applications)* modeling & simulation**

- **Alternative trades and comparisons**

- **Prototype - application performance verification demo/testing**

- **Field trials to enable feedback from users & stakeholders**

- **Refine feasibility CONOPS & implementation planning**

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